Lightning Protection for the Amateur Radio Operator's Home

Lightning protection is a safe investment for any station.

Jennifer Morgan and Michael Chusid

It is every radio operator's worst nightmare. Millions of volts suddenly leap out of the sky, striking your home, antenna, or other conductive surfaces. Billions of watts race down transmission lines or through the building's structure, destroying your transmitter, amplifier, receiver, or other elements of your radio apparatus. Your prized station is now just trash. And if you happen to be online when the "signal" comes in, you could be toast, too!

Congratulations — you have just become a victim of one of the approximately 25 million lightning strikes that occur in the United States each year. You have learned the hard way that in the contest between lightning and your equipment, lightning usually wins.

An excellent, three-part article on "Lightning Protection for the Amateur Radio Station," by Ron Block, KB2UYT (now NR2B), was published in the June, July, and August 2002 issues of *QST* and provides sound guidelines for protecting your station.[1] But as stated in Part 1 of the series, the goal is "to establish a 'zone of protection' within the radio room, as opposed to the whole house or building." The particulars of protecting the unique electronics in a radio setup are beyond the scope of this article, and a specialist may need to be consulted. This article recommends that the protection of your equipment begins with protecting a seemingly minor accessory to your station — *your home*.

Special Risks for the Amateur

Lightning strikes pose special risks for the Amateur Radio operator. To increase signal coverage, operators often place their antennas as high as possible — for example, on towers or rooftops — increasing the risk of being at the receiving end of a strike.

When an enthusiastic amateur upgrades their station, he or she inadvertently becomes more vulnerable. That's because, as radio equipment improves, electronic circuits become miniaturized and, thereby, more susceptible to damage from energy surges.

Amateur Radio operators take pride in being of service during emergencies. Unfortunately, lightning strikes occur during hurricanes, tornados, forest fires, floods, blizzards, and other extreme weather events. Emergencies are the exact time that Amateur Radio operators are needed the most, and the worst time to discover latent damage or degradation.

Unfortunately, several myths about lightning protection come into play.

Myth 1: I don't need a lightning protection system (LPS) because lightning strikes are rare.

According to the Insurance Information Institute, claims for lightning losses cost nearly a billion dollars in

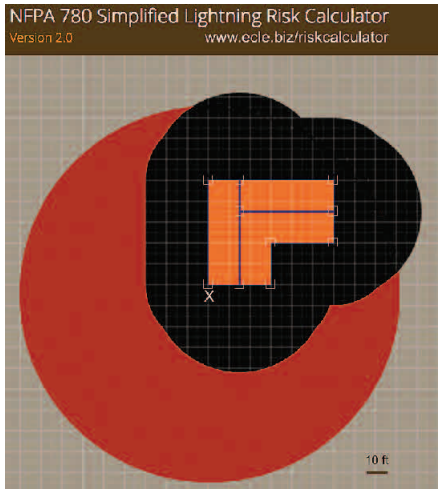

Figure 1 — In this drawing, taken from an online lightning risk assessment, orange shows the footprint of a one-story house with a 10-foot eave height and a 14-foot ridge height. The brown area shows the "collection area" that contributes to the building's vulnerability to lightning. When a 30-foot-tall antenna is added to the lower left corner of the house (X), red shows increased size of the collection area due to the antenna's height. [Photo courtesy of East Coast Lightning Equipment, Inc.]

2015. From 2010 to 2015, the average cost per claim rose 64%. These figures understate losses because much damage is not reported (or is not included because of deductibles), or is attributed to equipment malfunction instead of lightning. In addition, the frequency of lightning strikes appears to be increasing.

Keep in mind that low risk is not the same as no risk. Tennessee generally has a lower number of lightning strikes than Florida, but still had $24 million in homeowner lightning damage claims in 2015. Even in low-risk southern California, lightning storms caused deaths and injuries, set fire to homes, and knocked out power to Los Angeles International Airport — even at the height of last year's drought.

Myth 2: I don't need an LPS because my antenna is not the tallest structure around.

Lightning is going to go wherever it wants to. Lightning protection standards treat lightning as if it were a 300-foot-diameter sphere rolled across the surface of a building (see Figure 1). Any place the sphere contacts the building is a location where lightning can attach. The point of contact might be your antenna, but could just as readily be another point on the house. Moreover, lightning need not directly strike a structure to cause damage. The energy of a lightning strike can "side flash" from one object to another. Also, lightning can travel to your structure through metal objects (such as wire fences, plumbing, and cables) and even through the ground.

Myth 3: I don't need an LPS because I connected my antenna to a metal ground rod.

An LPS is more than just a wire to a ground rod (see Figure 2). The Insurance Information Institute cautions:

> Keep in mind lightning protection system design and installation is complex and not a do-it-yourself project. Installation is not typically within the scope of expertise held by general contractors, roofers, or even electricians, which is why the work is typically subcontracted out to specialists.[2]

Lightning Protection Fundamentals

Lightning typically begins within a cloud, where ice particles collide and generate static electricity. When the charge within the cloud grows sufficiently, the electrical insulating properties of air fail, and an ionized conductive channel to the opposite charge is established. The rapid discharge of electricity along this channel is lightning, both cloud-to-cloud and cloud-to-ground.

The power of a lightning strike is daunting. In 0.2 seconds, the air around the conductive channel can heat up to 50,000°F. An object in the path of a lightning strike may be subjected to as much as 3 million volts.

Lightning seeks the path of least resistance to ground. If the path is through your home, it could cause fire or structural damage. If it is through you, it could cause serious injury or death. And if it is through your equipment, you're likely to lose that equipment (see Figure 4).

Figure 2 — The braided copper cable and large clamp are UL-listed for lightning protection and are much larger than the wire and clamp (near the top of the ½-inch-diameter grounding rod) required for ordinary household grounding. The two grounds are bonded to create a common ground point. [Photo courtesy of East Coast Lightning Equipment,

Lightning protection systems work by creating an adequately sized, low-resistance path for lightning to flow around a structure into the Earth. An LPS should be designed and installed in compliance with the following standards (see Figure 3), based on technologies and principles that have been proven over the past 200 years:

- National Fire Protection Association (NFPA) 780 — *Standard for the Installation of Lightning Protection Systems.*[3] UL (formerly known as Underwriters Laboratories) 96A — *Installation Requirements for Lightning Protection Systems* and 96 — *Lightning Protection Components*
- Lightning Protection Institute (LPI) 175 — *Standard of Practice for the Design — Installation — Inspection of Lightning Protection Systems;* National Standard of Canada, CAN/CSA-B72-M87 — *Installation Code for Lightning Protection Systems* (applies to projects in Canada).

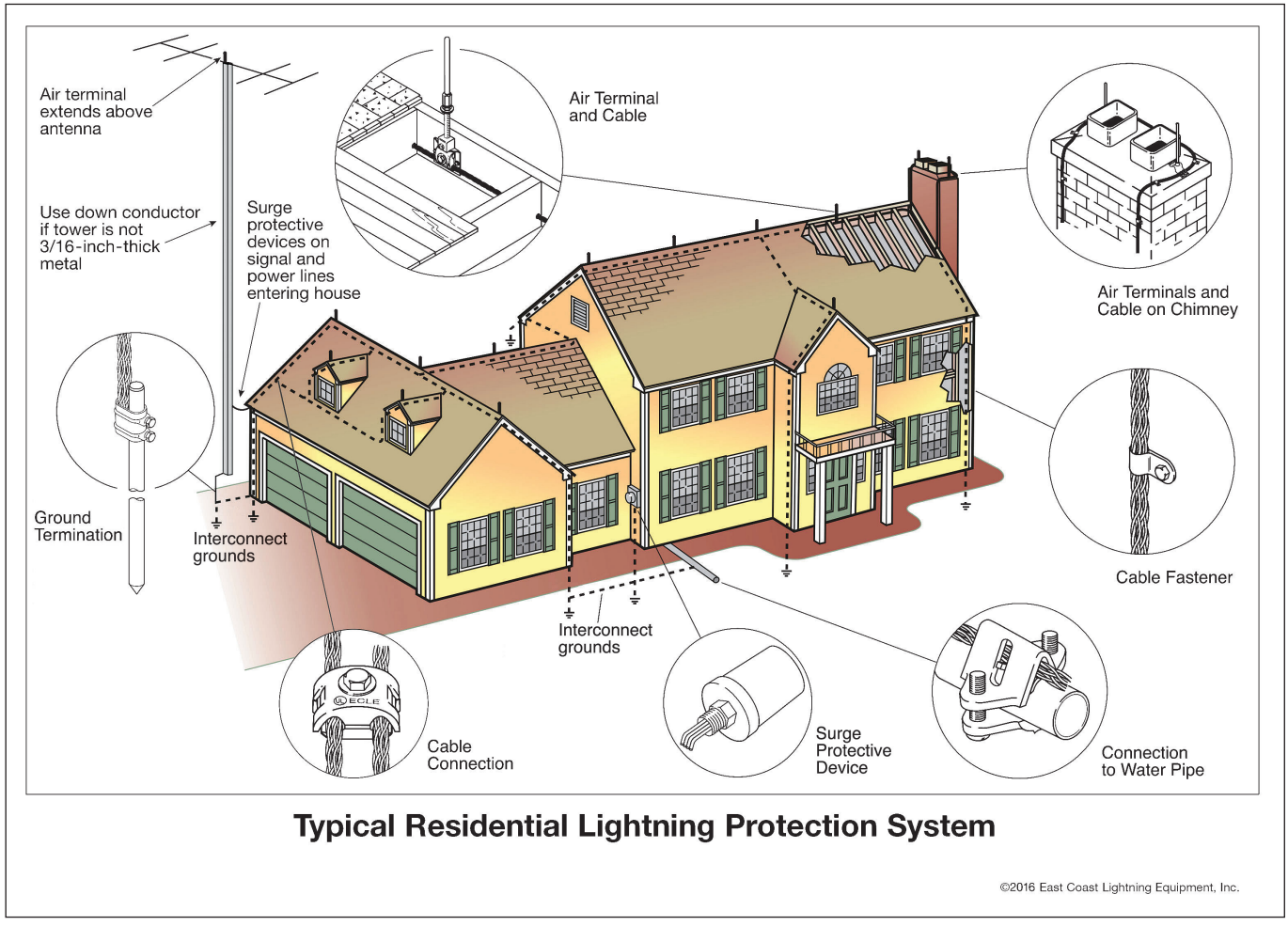
Air terminal extends above antenna
Use down conductor if tower is not 3/16-inch-thick metal
Surge protective devices on signal and power lines entering house
Air Terminal and Cable
Air Terminals and Cable on Chimney
Ground Termination
Interconnect grounds
Interconnect grounds
Cable Fastener
Cable Connection
Surge Protective Device
Connection to Water Pipe
Typical Residential Lightning Protection System
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Figure 3 — Your station is not safe unless the building in which it is installed is also protected. A complete lightning protection system includes many components designed and installed to meet the standards of NFPA, UL, and LPI. [Photo courtesy of East Coast Lightning Equipment, Inc.]

Compliance with building codes governing normal electrical systems is not enough to protect against lightning. As stated in the International Association of Electrical Inspectors (IAEI) handbook, *Soares Book on Grounding and Bonding*, the "installation of a lightning protection system is much different from the installation of electrical service wiring." Furthermore:

> Specialized material and installation methods, such as that specified in NFPA 780 and UL 96, are required, and the system should only be installed by qualified personnel trained and certified in the installation of lightning protection systems.

Components

All components must be UL listed for lightning protection; UL-listed prod-

Figure 4 — Lightning destroyed this antenna. A properly designed and installed lightning protection system could have prevented this damage and provided protection for the owner's home and its contents.

ucts for electrical services are inadequate for the overwhelming force of lightning.

Components are made from high-grade aluminum, copper, or copper alloys due to their high electrical conductivity. Project conditions and adjacent building materials determine which of these metals can be used.

Air Terminals

Located at the top of a building, these are usually the first elements of an LPS that engage lightning strikes. Air terminals, colloquially known as lightning rods, can be as small as ⅜ inches in diameter by 10 inches tall. They are available in a variety of metals and styles to complement the design of your home.

Air terminals must be installed at the ends of roof ridges and corners of roof parapets, and at a maximum of 20-foot intervals. They must also be on high points, such as chimneys, antennas, and rooftop equipment (see Figure 5).

Figure 5 — Existing buildings can be retrofitted with lightning protection systems. [Photo courtesy of Mr. Lightning]

We caution against the use of so-called "early streamer emissions," "dissipation array," and "charge transfer" air terminals. Claims that these devices "attract" or "repel" lightning have been debunked by NFPA, court rulings, and international studies. The devices can function as individual air terminals if used in accordance with NFPA 780, but they do not reduce the quantity of air terminals needed to protect a building.[4]

Conductors

Made from multi-strand copper or aluminum cables, conductors connect the components of the LPS. The diameter of the cables is much larger than the wires used in home electrical service, allowing lightning to pass without sufficient resistance to generate heat (see Figure 6). This is important because cables may be near wood or other combustible materials in your house.

At least two widely separated down conductors are required for any structure. Larger structures and buildings with more complex rooflines will require more. An antenna tower or structural element can be used as a down conductor if it is made of metal at least 3⁄16 inches thick and is electrically continuous.

Bonding

No LPS is an island. Lightning flows through every conductive path to ground that it can find, including structural elements, piping, ductwork, coaxial cables, and other components. Even if these elements are grounded, they need to be interconnected to the LPS using appropriately sized bonding connectors. Otherwise, current will arc from one path to another with lower electrical potential.

Grounding

Every down conductor must connect to a grounding electrode. In most cases, copper-clad steel grounding rods are driven 10 feet into the ground, and must be located at least 2 feet outside of a structure's perimeter. Each grounding electrode must be interconnected with the other electrodes and with the building utility ground. Other grounding configurations, such as copper ground plates, may be required in dry sand and rocky soils or when building on rock (see Figure 7).

Surge Protective Devices

A surge protective device must be installed on every power, coax, signal, and other type of wiring entering your home. The devices must comply with NFPA 780 and, as applicable, either UL 1449 — *Standard for Surge Protective Devices* or UL 497 — *Standard for Protectors for Paired-Conductor Communications Circuits*. Installation is a job best performed by a licensed electrician. An Amateur Radio operator, however, can design and install a zone of protection to safeguard against transient surges.

Surge protective devices should be

Figure 6 — A professional lightning protection installer can show you how to reduce the cost of an LPS. Here, for example, a conductor from the roof is connected to a steel column that acts as the conductor to the floor level and an external ground system. [Photo courtesy of Priestley Lightning Protection, LLC]

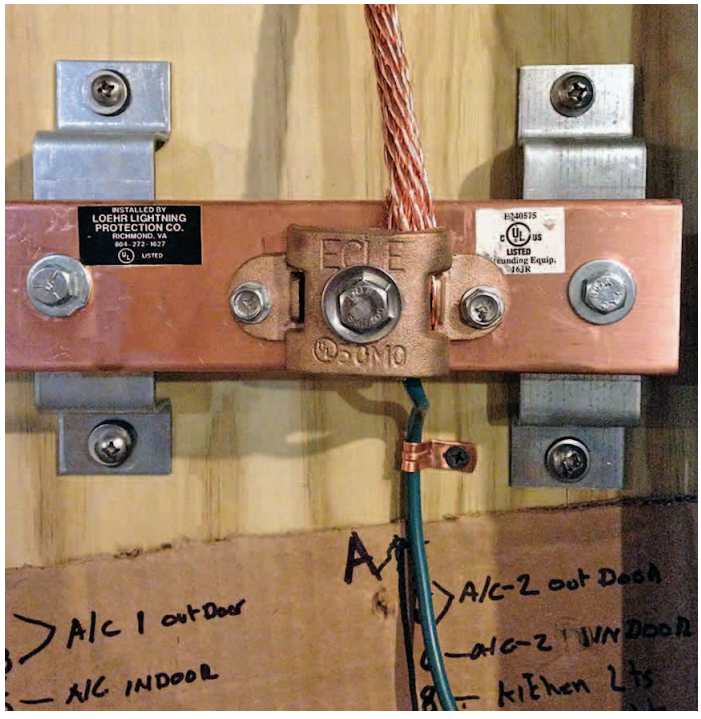

Figure 7 — This copper bar provides a convenient location to interconnect the grounds for various systems in the house. The braided copper cable is listed for use in lightning protection systems and leads to an interconnected ground system. [Photo courtesy of Mr. Lightning]

Figure 8 — Because much of a lightning protection system must be installed on rooftops or other high locations, it is advisable to have a trained professional with adequate protective gear do the work. [Photo courtesy of Labeled Lightning]

checked for damage at regular intervals.

Lightning Protection System Risk Evaluation

Not every building can justify the cost of an LPS. Fortunately, NFPA 780 has a "Simplified Risk Assessment" that you can use to evaluate your home's susceptibility to lightning damage. A qualified LPS designer can assist you with the risk assessment. Alternatively, you can run the calculations yourself using a free app, such as the one at **ecle.biz/riskcalculator**. It will ask you the following about your home:

- *Building size and height.* The size is based on the roof area of the building. The height includes the height of antennas, chimneys, and other rooftop equipment.
- *Frequency of lightning in your local area*. A map with this data is available at **ecle.biz/lightning-risk-map**.
- *Structures or trees near the building*. Structures that are taller than surrounding trees and buildings, or that are located on a hill, are at greater risk.
- *Structural and roofing materials.* Metal framing and roofing is less vulnerable to lightning damage than combustible materials are.
- *Value and combustibility of the building's contents.* In addition to your radio station, your home entertainment system, art collection, and other expensive features may justify a higher level of protection. Combustibility is another consideration; an empty metal shed will obviously need less protection than a wooden home owned by a Civil War reenactor who likes to store gun powder.
- *Occupants*. Risk increases if it will be difficult to evacuate children or other occupants.
- *Consequences of a strike*. If your family is willing to move out while lightning damage is being repaired, you are at a lower risk than if you want your equipment to be operable in an emergency.

Once risk factors are entered, the easy-to-use app performs the appropriate calculations to make a determination of your home's vulnerability to lightning. If the risk is greater than what is deemed the acceptable level of vulnerability, a building lightning protection system is recommended.

Buying and Maintaining an LPS

The IAEI recommends that only LPI-certified or UL-listed lightning protection specialists be contracted to design and install your LPS. Make sure your contract specifies that their work complies with the standards listed above (see Figure 8).

For extra confidence or to get lower rates from your homeowner's insurance provider, you may wish to have a third-party inspection service, such as the Lightning Protection Institute – Inspection Program (LPI-IP), inspect and issue a certificate that the LPS is installed correctly.

Once an effective system is in place, NFPA 780 recommends periodic maintenance to ensure that it stays in

Figure 9 — LPS components must be UL-listed specifically for lightning protection. Clockwise from upper left: Air terminals, conductor cables, surge protective devices, and connectors. [Photos courtesy of East Coast Lightning Equipment, Inc.]

ARRL Field Day and Lightning Awareness

Across much of the US, Field Day is conducted in thunderstorm country. Every visitor to your Field Day site will appreciate the opportunity to learn about lightning detectors, especially with the eye-catching online maps at lighting detection websites like **www.lightningmaps.org** and **en.blitzortung.org/live_lightning_maps.php?map=30**. While they are looking at the maps, you can be building a lightning detector kit like this one from **www.easternvoltageresearch.com/lightningdet10.html**, or showing them how a commercial unit works to detect local lightning activity. (Detectors are available starting at about $60.) And you do have a National Weather Service radio, too, right? Tie it all together for your visitors and you'll be a thundering success!—*Ward Silver, NØAX*

compliance. Remodeling, reroofing, digging near the foundation, or the addition of antennas, satellite dishes, and rooftop equipment can compromise the efficiency of a lightning protection system, so it is worth having a lightning protection professional inspect the system on a regular basis. You may *believe* you are protected against lightning, but it is far better to *know*.

Don't Gamble with Lightning

A recent cost survey for professionally-installed LPS is available online at **ecle.biz/coststudy**. Antennas, extra surge protective devices (see Figure 9), and complex roof designs, will increase this estimate. Still, the cost of installing lightning protection on a typical home can cost less than many amateurs have invested in all the equipment, towers, and antennas required for their stations.

The chances of lightning strikes often increase during weather emergencies when Amateur Radio stations are most needed. Your station can help protect your fellow citizens, yet it is the lightning protection system over your head that protects *your* life and property. When designed and installed according to recognized standards, an LPS protects more than your radio station.

Notes

[1]**www.arrl.org/lightning-protection**

[2]**bit.ly/insurance-press-release**

[3]The current edition can be viewed at **bit.ly/NFPA-780**

[4]J. Morgan and M. Chusid, "Not all Lightning Protection is Created Equal," *Electrical Business*, Sept. 2016, **bit.ly/NonConformingLightningProtection**

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